

February 2, 1991

To: Tern Island Files

From : Tern Island Staff

1990

SUMMARY OF GREEN TURTLE STUDIES AT TERN ISLAND,
FRENCH FRIGATE SHOALS, 1986 - 1990.

In 1986, the U.S. Fish and Wildlife Service in cooperation with the National Marine Fisheries Service began to monitor green turtle (Chelonia mydas) nesting activity at Tern Island, French Frigate Shoals. The general objectives of this multi-year study are: to monitor nesting and hatching phenologies, hatching success, locations of nests on Tern Island, avian and ghost crab predation on turtle hatchlings, and to determine whether man-made debris are responsible for entrapment of turtle hatchlings.

The Tern Island facilities are staffed year-round by FWS employees and volunteers. This year-round presence makes studies of seasonal nesting and hatching phenologies more practical than at other locations (i.e. East Island) where the logistics of operating 8 or 9 month field camps become formidable. Another major consideration in conducting turtle research on Tern Island is related to the condition of the seawall. The Tern Island seawalls will need to be replaced, removed, or left to continue rusting away. Information on green turtle use of Tern Island (nesting and hatching phenologies, location of nests, numbers of turtles nesting on Tern Island, numbers of hatchlings produced, etc.) will be an important consideration in making a decision on the fate of the seawalls:

This document contains a summary and copies of the 1990 Tern Island green turtle nesting activity data. Summaries of 1986, 1987, 1988, and 1989 data are also included for between-year comparisons. Data includes: nesting and hatching phenologies, hatching success, incubation lengths, nest locations, and a listing of female turtles observed "nesting" at Tern Island. Copies of previous year's data can be found in the "Summary Report" for each respective year with the exception of 1986's data which is included in the 1987 "Summary Report" which covered both 1986 and 1987.

The 1988 and 1989 "Summary Reports" contain the results of a study examining great frigatebird (Fregata minor) predation of turtle hatchlings. We found no evidence that great frigatebirds prey upon turtle hatchlings. A manuscript is being prepared so that this information can be published.

STUDY AREA

Tern Island (Lat. 23 52' N, Long. 166 17' W) is found on the northwestern rim of French Frigate Shoals (FFS), about 500 miles west-northwest of Honolulu, Hawaii. During World War II, the Navy enlarged the original 11 acre islet into a 57 acre island that could accommodate aircraft. The island resembles a small aircraft carrier and is about 3000 ft long and 120 ft wide. From 1952 to 1979, the U.S. Coast Guard operated a LORAN transmitting station at Tern Island. Since 1979, the U.S. Fish and Wildlife Service has occupied Tern Island for the purpose of managing the Hawaiian Islands National Wildlife Refuge, performing research, and assisting other agencies in research projects.

About 3000 ft. of Tern Islands south-facing shoreline provides easy access and good substrate for nesting green turtles. Most of the remaining shoreline consists of exposed seawall which prohibits access to the island. Two coral rubble beaches on the northern shoreline allow limited access to the Island.

METHODS

Research methods throughout the five years of this study were similar. See the METHODS sections of previous year's "Summary Reports" for exact details of methods used in those years. The following methods were used during the 1990 season.

To locate nests and monitor hatching, morning patrols of Tern Island beaches were conducted between 25 April and 17 December, 1990. In addition, during the nesting season, night patrols (once nightly, anytime between sunset and midnight) were conducted. The objective of these night patrols was to identify any nesting females encountered. To eliminate as much disturbance as possible to the Hawaiian monk seal (Monachus schauinslandi) and seabird populations, these patrols were limited to the beach zones (at night, most seals "haul out" and are in the interior, vegetated zone of the island). Turtle researchers entered the interior zones of the island only when following tracks of turtles that came ashore.

Nest Locations:

Locations of nests were determined by either observing the turtle laying eggs or by observing the physical characteristics of the turtle's diggings. Usually, a successful nesting attempt can be differentiated from unsuccessful "false pits" by the distinctive evidence of back-filling or covering of the nest. Also, after completing a nest the turtle will normally return directly to the ocean.

If a researcher was relatively confident that a female's effort resulted in a nest (eggs seen or all the appropriate signs were present) the nest site was marked with a numbered stake placed about 150 cm (5 feet) inland of the nest. If the researcher was unsure if there was a nest, the site was assigned a M-series number meaning that all the signs of a successful nesting were not present; however, there was enough digging that possibly there was a nest there. These M-series nests (maybe nests) were not marked with a stake. However, locations of both types of nests (marked with stakes and the M-series) were recorded on appropriate maps and data forms. Every time a female turtle comes ashore and does any digging that could have even remotely been a nest the site should have at the very least been given a M-series denotation. We should have the lay date for all nests that subsequently hatch. This liberal system will result in sites being marked as nests or M-series nests that are in fact not nests. Nest sites where hatchlings do not emerge will be dug up after 100 days to verify that a nest was or was not present.

Nesting Female Identification:

As in 1989, because of personnel constraints, no extensive effort was undertaken to identify nesting females. Identifications were limited to turtles encountered on the twice daily beach patrols (night and early morning). An effort was made to read any existing tags on each turtle encountered. If the turtle was not tagged, tags were applied. A curved carapace length and any distinguishing physical characteristics (tumors, etc.) were recorded for each turtle. After a turtle was identified and examined, a temporary 1989 study number and letter was engraved and painted onto the carapace. This temporary identification expedited re-identification of the turtle on subsequent visits, reducing both disturbance to the turtle and effort required by the researcher. Identification, tagging, and/or any other activity that would disturb the turtle was not performed while the turtle was excavating a nest or laying eggs. Identification activities were accomplished either before nesting or after egg laying.

Tags were applied to either the primary sites (proximal locations on the front flippers) or secondary sites (further out on the front flippers). We tried to ensure that at least two well applied tags were on each turtle. Tags and tagging procedures were provided by George Balazs of the National Marine Fisheries Service.

Incubation Length and Hatching Success:

Hatchling emergence was monitored by observing each nest site starting about 50 days after eggs were laid. Almost all

"hatching" nests can be detected on the day the hatchlings emerge by watching for pre- and post- emergent pit formations and tracks of hatchlings. Sometimes hatchlings will emerge from a nest on more than one night. In that case, the first night hatchlings emerged was recorded as the date of emergence for that nest. If a nest had not "hatched" within 100 days, the nest was excavated and contents analyzed.

We waited an additional three nights after initial hatchling emergence before the nest was excavated to determine clutch size and hatching success. We determined the number of successfully emerged hatchlings by counting hatched egg shells. The remainder of the nest's contents were categorized as follows: bad eggs (infertile and/or rotten), dead embryos (1/4, 1/2, and 3/4 developed), dead fully developed hatchlings, and live hatchlings trapped in the nest. Any trapped hatchlings were released that night. Trapped hatchlings were kept in a bucket covered with a damp rag and stored in the dark until time for their release. After analysis, all nest materials were returned to the excavated pit and buried. For the 1990 season, the "trapped in the nest" category should be further defined as the number of live hatchlings that remained in the nest four days after initial hatchling emergence.

If the lay date or hatchling emergence dates of any nests were missed, the mean incubation length for all the other 1990 nests was used to calculate the missing parameter so that the nest could be included in the year's phenology data.

RESULTS AND DISCUSSION

In 1990, 90 nests were located on Tern Island. This was down 13 nests from the 103 found in 1989. However, the number of nesting females identified on East Island was 42.8% lower this year than in 1989 (based upon the number of females identified by saturation tagging: 158 and 276 in 1990 and 1989, respectively). Comparatively, the number of nests on Tern Island dropped only 12.6%. I think that these data show that the increasing importance of Tern Island to the nesting population at FFS observed in the last few years (Figure 1.) is continuing.

Nesting and Hatching Phenologies:

In 1990, the first and last Tern Island green turtle nests were laid on 9 May and 25 September, respectively (Figure 2.). The first and last hatchlings emerged on 13 July and 17 December, respectively. Lay and hatchling emergence dates for individual nests can be found in Appendix A. For comparison to previous years, Figure 3 shows the nesting and hatching phenologies of 1989, 1988, 1987, and 1986. The dates of first and last nests laid and first and last hatchling emergences for these four years are: 28 April, 28 September, 19 July, and 27 December for 1989;

26 April 1 October, 8 July, and 9 December for 1988; 25 May, 20 October, 29 July, and 26 December for 1987; and 6 June, 22 September, 15 August, and 16 November for 1986; respectively. A monthly breakdown of nesting and hatchling emergence activity on Tern Island during the last 5 years is presented in Tables 1 and 2, respectively.

The phenology data for 1990, 1989, and 1988 were combined to give an overall view of nesting and hatchling emergence. The 1986 and 1987 data were not included because during those years we did not have the opportunity to verify that the nesting activity on Tern Island was representative of activity throughout FFS. It is possible that the number of females using Tern Island those years were not enough to give a complete picture of nesting and hatchling emergence phenologies. For the last three years, we have been able to verify that the Tern Island activity was representative of atoll-wide activity by visiting East and Whaleskate Islands throughout the nesting season. The combined phenology data for the last three years is presented in Tables 1 and 2 and illustrated in Figure 4. During these three years, the dates of the earliest and latest nests laid were 26 April and 20 October, respectively. The dates of first and last hatchling emergences were 8 July and 27 December, respectively.

Nest Locations:

All but eight of the 90 nests were located on the south-facing shoreline (Figure 5.). Of the eight exceptions, five were found on Crab Beach and three on Shell Beach. The nest locations during 1989 through 1986 are shown in Figures 6 through 9, respectively. More detailed locations for the 1990 nests can be found in Appendix B.

Identification of Nesting Turtles:

In 1990, identification was limited to turtles encountered on twice daily (one between sunset and midnight and one in the early morning) beach patrols. We identified 28 females: 19 were previously untagged, six were already tagged, and three were identified at East Island (tagging information for the East Island turtles not available at Tern presently). Five of the previously tagged females had been recorded as nesting on Tern Island in preceding years (3 in 1987 and two in 1988). A list of the turtles identified on Tern Island in 1990 can be found in Appendix C, Table 1C. Identifications from preceding years can be found in Table 2C, Appendix C.

Number of Nests/Female:

We could not attempt to identify females for all nests because of personnel constraints; thus, no estimate of the number of nests per nesting female could be made.

Nesting Turtles Trapped By Man-made Obstructions:

In 1990, five females (one in May, three in June, and one in August) were discovered wandering around on the runway after sunrise. Most of these turtles had come ashore at Crab or Shell Beaches and had not been able to find their way back to the ocean because of the north seawall. All of these turtles were guided back to the ocean.

Incubation Periods:

Incubation periods (number of days from eggs being laid to hatchling emergence) were calculated for all nests with known lay and hatchling-emergence dates. The mean incubation length for 1990 was 66.2 days with a range of 54 to 91 days (based upon 73 nests) (Table 3.). Means for previous years ranged from 63.0 to 70.5 days. Combining data from the last five years gives us an overall mean of 66.6 days with a range of 53 to 97 days (based upon 301 nests) (Table 3.)

The wide range of incubation periods (53 to 97 days) can not be explained by genetic differences in nesting females, as the incubation periods of nests laid by the same female in the same year show a similar wide range of values. For example, in 1988, one female laid nests that hatched at 56, 61, 63, 66, and 76 days. Another possible factor is nest site characteristics. In 1988, when incubation periods of nests within 10 meters of the beach crest (point where the beach starts sloping to the ocean) were compared to incubation periods of nests greater than 10 meters from the beach crest, we found significant differences (at $p=0.07$ level, TTest) in mean incubation lengths: 64.7 (SD=5.73, $n=57$ nests) and 58.7 (SD=3.90, $n=19$ nests) days, respectively. This is a gross comparison as many factors are probably involved: moisture and organic contents of nesting substrate, elevation above sea level, if the nest site is shaded or not, nest chamber depth, etc.

Clutch Size:

In 1990, we found a mean clutch size of 91.4 eggs with a range of 33 to 138 eggs (Table 4.) Respective mean clutch sizes for 1989, 1988, 1987, and 1986 were 89.0, 96.8, 85.6, and 86.7 eggs (Tables 5, 6, 7, and 8, respectively). The smallest and largest clutches encountered during the last five years on Tern Island are 33 and 146 eggs, respectively.

COMMENTS

Continued monitoring of green turtle nesting on Tern Island will allow us to delve deeper into the breeding biology of this species. In addition to developing better databases for the topics already discussed, we can examine topics such as: clutch size and hatching success in subsequent nests from the same female, hatching success of nest laid early in the season compared to ones laid in mid-season or at the end of the season, nest site characteristics, nest and nesting beach temperature profiles, etc. Ghost crab predation of turtle hatchlings also needs to be documented better. Previous attempts to study this topic have failed because any type of lighting that allows researchers to observe the beaches disrupts ghost crab behavior. What we need to accomplish this study is some type of night vision equipment. On Tern Island, we can see pre-hatch pits on about 70% of the nests the day before hatchlings emerge. So if we had the night vision equipment for two months (15 August to 15 October) and somebody dedicated to the project for the same two months we could probably observe hatchlings from 50 or more nests.

Figure 1. Green turtle nesting-activity trend at Tern Island, 1986 - 1990.

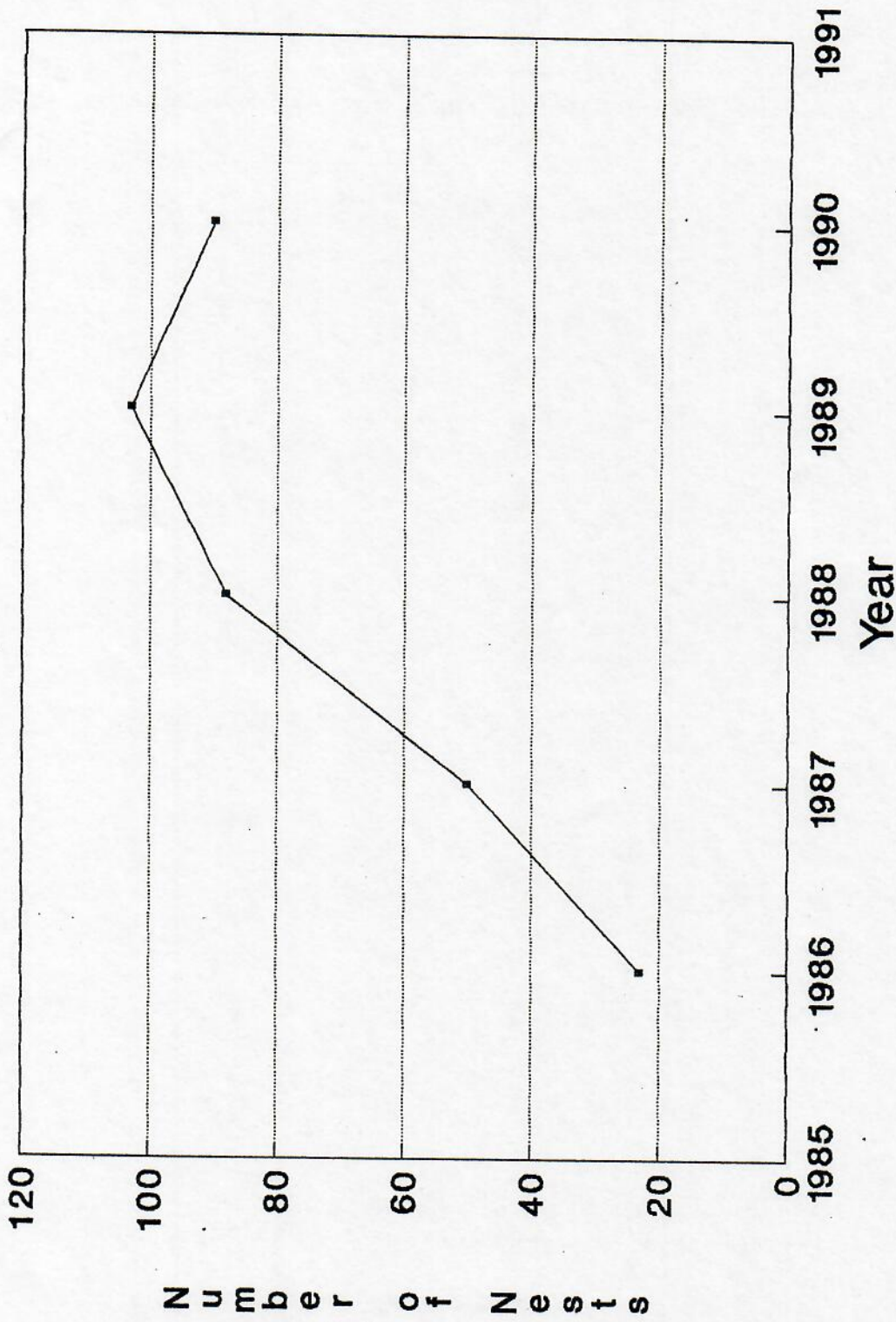
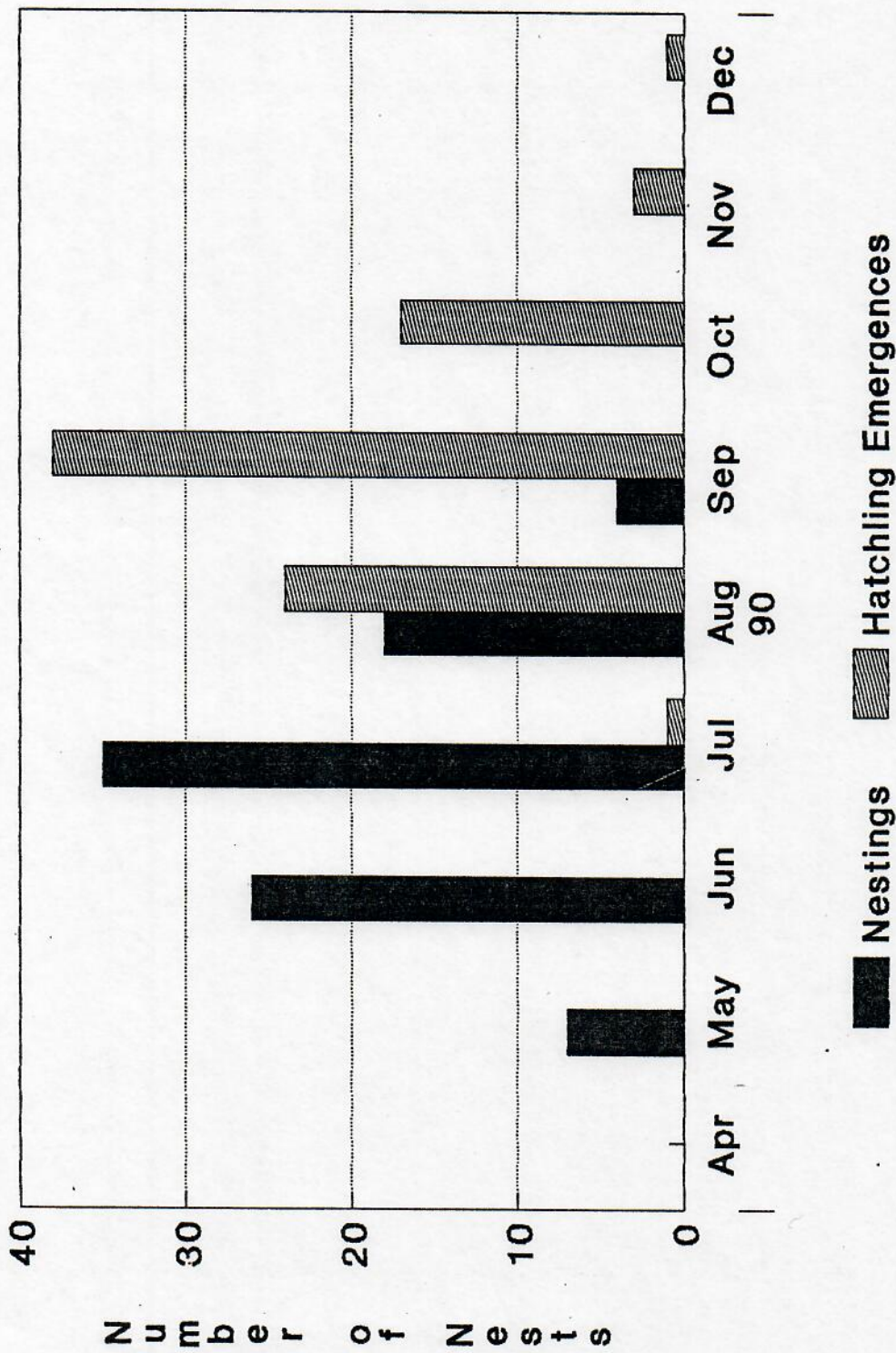


Figure 2. Green turtle nesting and hatchling emergence phenologies at Tern Island, 1990.



Ninety nests were observed. Eighty-four of these hatched.

Figure 3. Tern Island phenologies, 1986 - 1989.

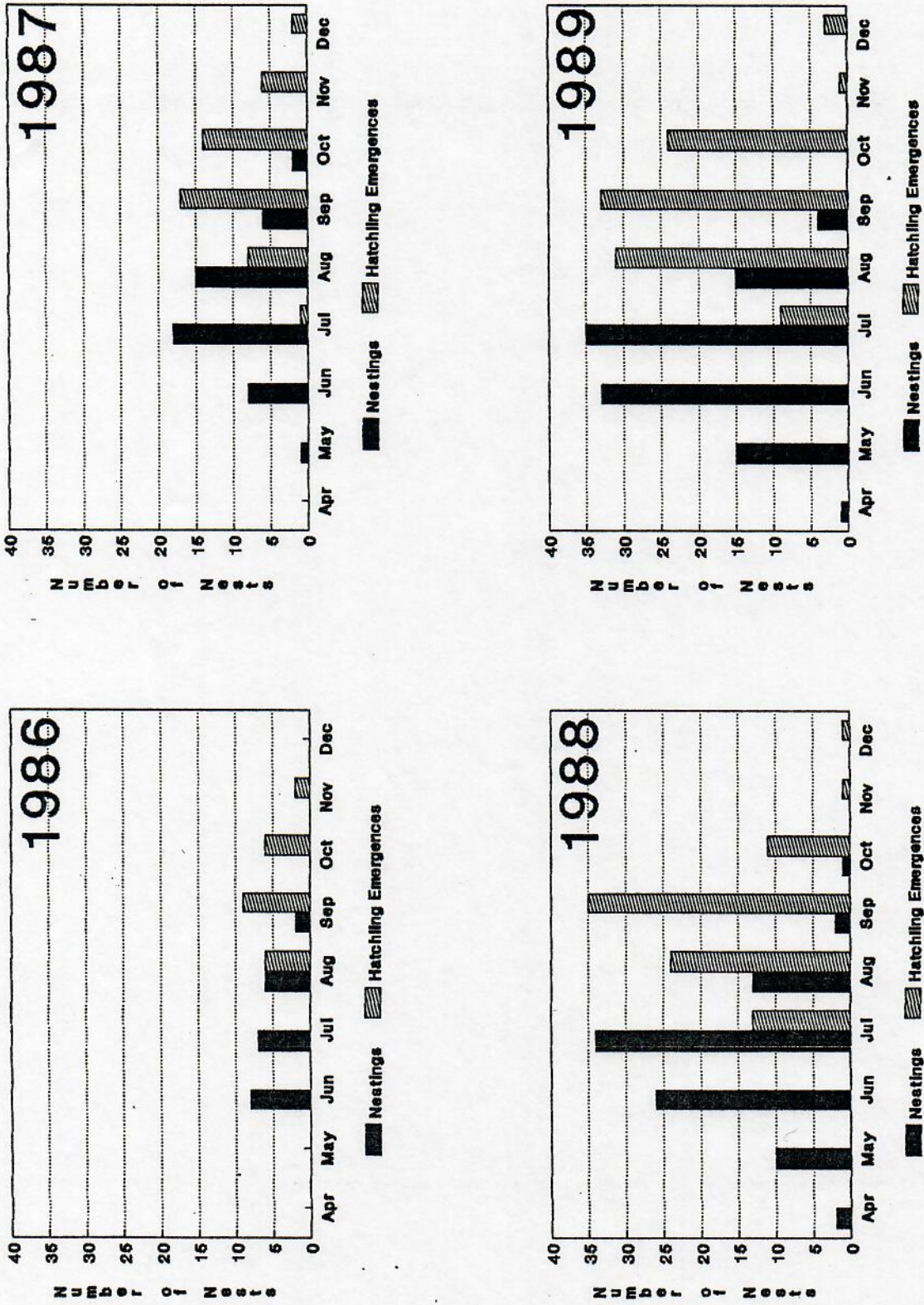
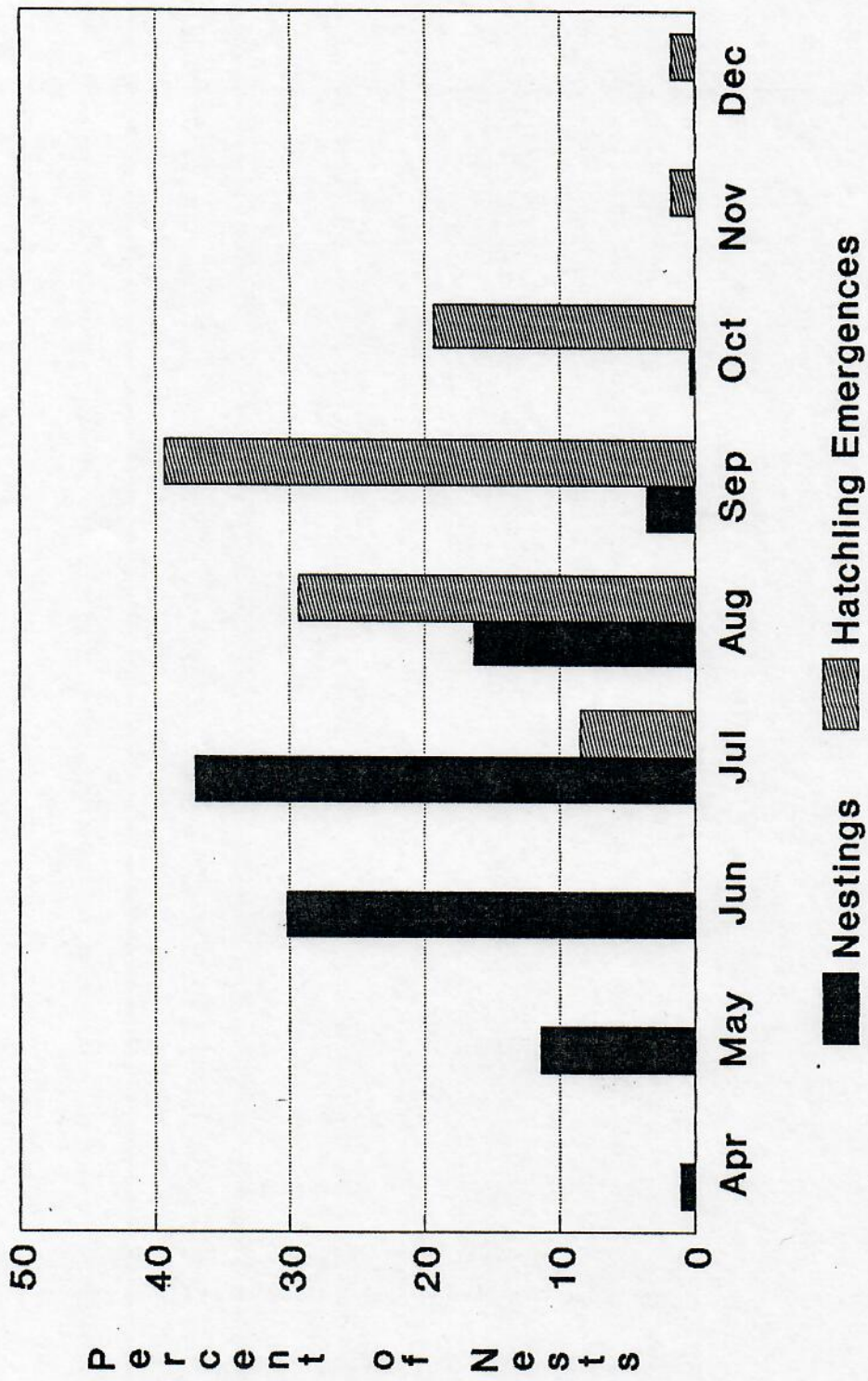
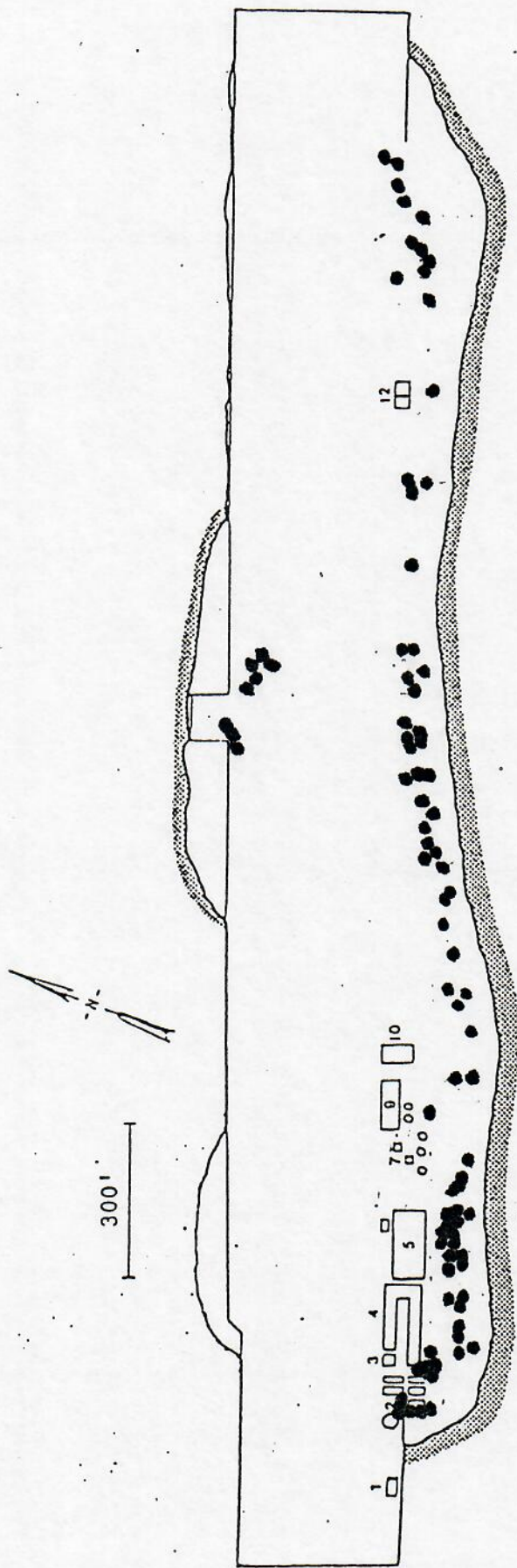


Figure 4. Combined nesting and hatching emergence phenologies at Tern Island, 1988/89/90.



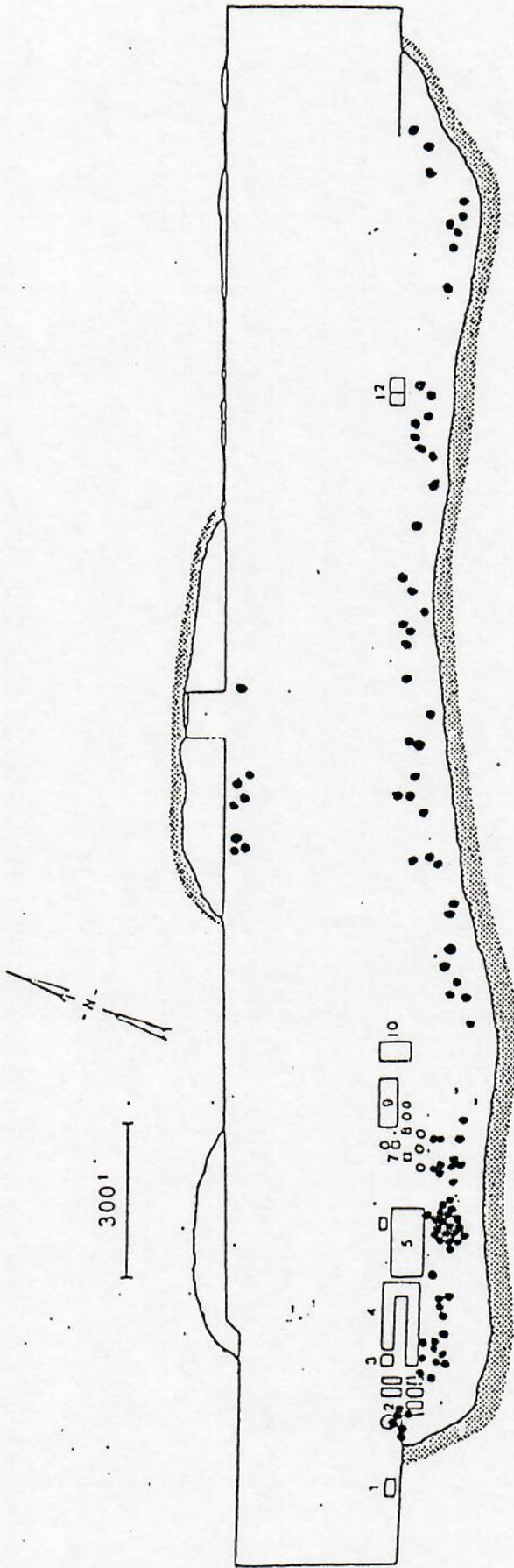
Data based upon 281 nests and 270 hatching emergences.

Figure 5. Locations of 90 green turtle nests found on Tern Island, French Frigate Shoals, 1990.



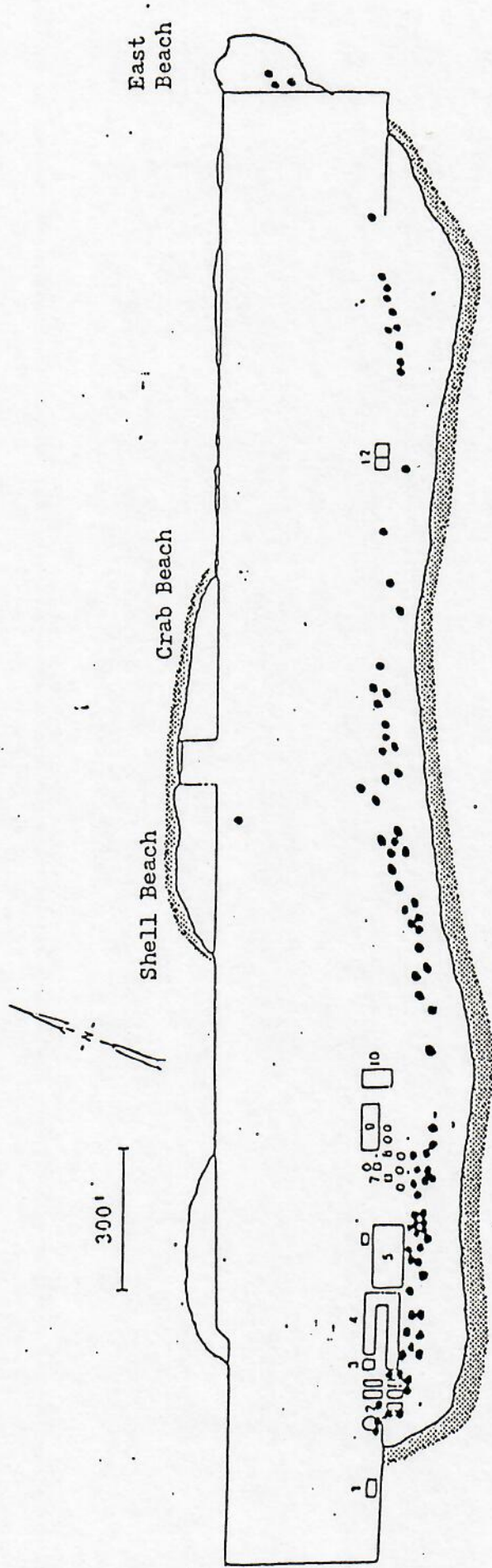
- | | |
|-------------------------------|----------------------------|
| 1. Boat House | 7. Pump House |
| 2. Fuel Oil Storage Tanks | 8. Fresh Water Tanks |
| 3. Garage | 9. Signal Power Bldg. |
| 4. Barracks-Subsistence Bldg. | 10. Old Signal Power Bldg. |
| 5. Recreation Court | 12. Storage Buildings |

Figure 6. Locations of 103 green turtle nests found on Tern Island, French Frigate Shoals, 1989



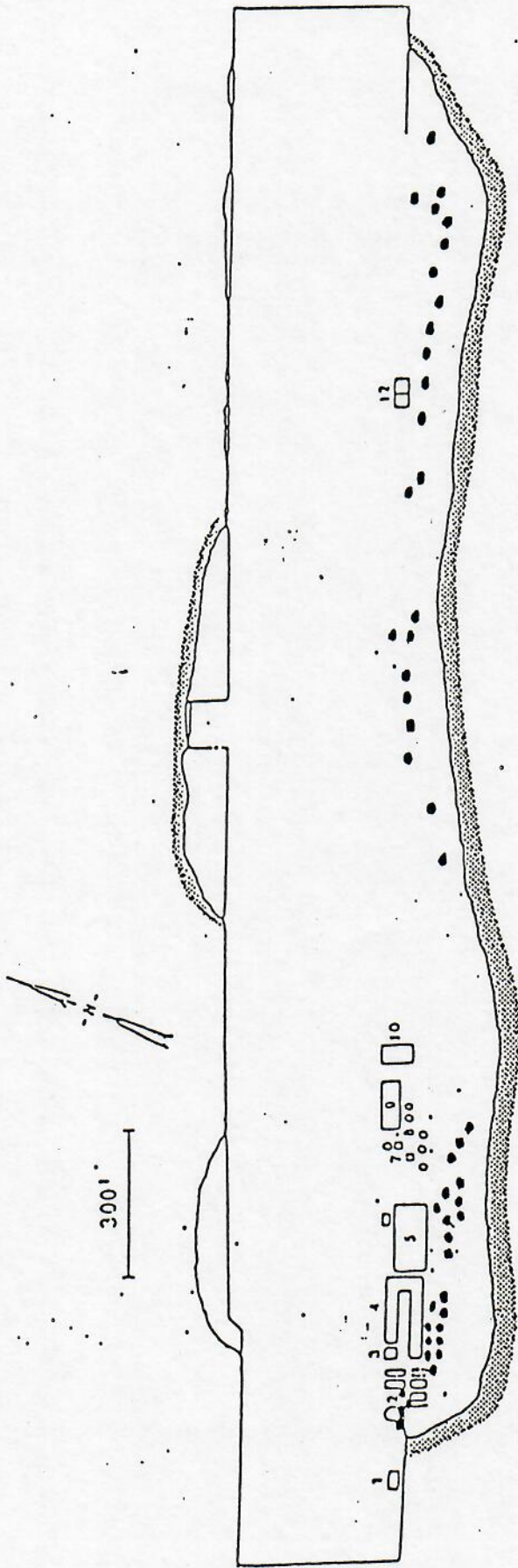
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|-------------------------------|----------------------------|
| 1. Boat House | 7. Pump House |
| 2. Fuel Oil Storage Tanks | 8. Fresh Water Tanks |
| 3. Garage | 9. Signal Power Bldg. |
| 4. Barracks-Subsistence Bldg. | 10. Old Signal Power Bldg. |
| 5. Recreation Court | 12. Storage Buildings |

Figure 7. Locations of 88 green turtle nests found on Tern Island, French Frigate Shoals, 1988.



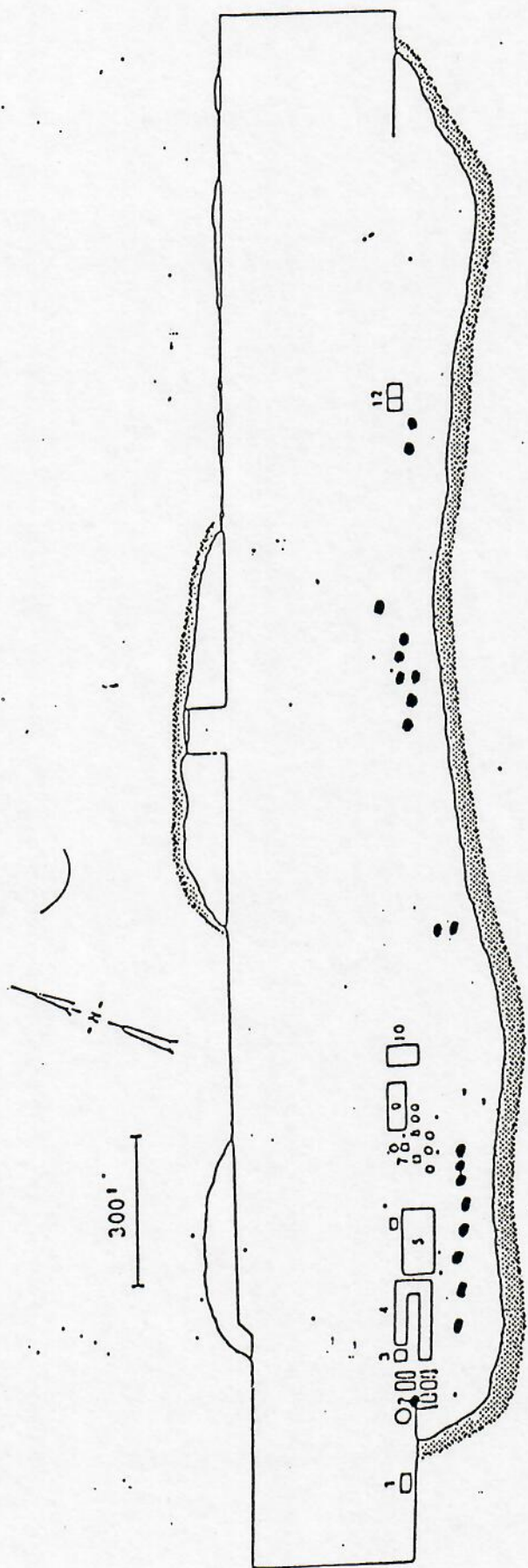
- | | |
|-------------------------------|----------------------------|
| 1. Boat House | 7. Pump House |
| 2. Fuel Oil Storage Tanks | 8. Fresh Water Tanks |
| 3. Garage | 9. Signal Power Bldg. |
| 4. Barracks-Subsistence Bldg. | 10. Old Signal Power Bldg. |
| 5. Recreation Court | 12. Storage Buildings |

Figure 8. Locations of 48 green turtle nests found on Tern Island, French Frigate Shoals, 1987.



- | | |
|-------------------------------|----------------------------|
| 1. Boat House | 7. Pump House |
| 2. Fuel Oil Storage Tanks | 8. Fresh Water Tanks |
| 3. Garage | 9. Signal Power Bldg. |
| 4. Barracks-Subsistence Bldg. | 10. Old Signal Power Bldg. |
| 5. Recreation Court | 12. Storage Buildings |

Figure 9. Locations of 20 green turtle nests found on Tern Island, French Frigate Shoals, 1986.



- | | |
|-------------------------------|----------------------------|
| 1. Boat House | 7. Pump House |
| 2. Fuel Oil Storage Tanks | 8. Fresh Water Tanks |
| 3. Garage | 9. Signal Power Bldg. |
| 4. Barracks-Subsistence Bldg. | 10. Old Signal Power Bldg. |
| 5. Recreation Court | 12. Storage Buildings |

Table 1. Nesting phenologies of green turtles at French Frigate Shoals, 1986 through 1990.

Year	Month										Total
	APR	MAY	JUN	JUL	AUG	SEP	OCT				
1990		7(7.8)	26(28.9)	35(38.9)	18(20.0)	4(4.4)					90
1989	1(0.9)	15(14.6)	33(32.0)	35(34.0)	15(14.6)	4(3.9)					103
1988	2(2.3)	10(11.4)	26(29.5)	34(38.6)	13(14.8)	2(2.3)	1(1.1)				88
1987		1(2.0)	8(16.0)	18(36.0)	15(30.0)	6(12.0)	2(4.0)				50
1986			8(34.8)	7(30.4)	6(26.1)	2(8.7)					23
Combined ²	3(1.1)	32(11.4)	85(30.2)	104(37.0)	46(16.3)	10(3.6)	1(0.4)				281

¹ Number of nests (% of total nests).

² Combined includes data from 1988, 1989, and 1990. The years where we verified that activity at Tern Island represented atoll-wide activity.

Table 2. Hatchling emergence phenologies of green turtles at French Frigate Shoals, 1986 through 1990.

Year	Month										Total
	JUL	AUG	SEP	OCT	NOV	Dec					
1990	1(1.2)	24(28.6)	38(45.2)	17(20.2)	3(3.6)	1(1.2)					84
1989	9(8.9)	31(30.7)	33(32.7)	24(23.8)	1(1.0)	3(3.0)					101
1988	13(15.3)	24(28.2)	35(41.2)	11(12.9)	1(1.2)	1(1.2)					85
1987	1(2.1)	8(16.7)	17(35.4)	14(29.2)	6(12.5)	2(4.4)					48
1986		6(26.1)	9(39.1)	6(26.1)	2(8.7)						23
Combined ²	23(8.5)	79(29.3)	106(39.3)	52(19.3)	5(1.8)	5(1.8)					270

¹ Number of nests (% of total nests).

² Combined includes data from 1988, 1989, and 1990. The years where we verified that activity at Tern Island represented atoll-wide activity.

Table 3. Incubation periods¹ of green turtle nests monitored on Tern Island, French Frigate Shoals, 1986-90.

Year	Mean	# Nests	Range	SD	SE
1990	66.2	73	54-91	7.81	0.91
1989	70.5	99	59-97	6.79	0.68
1988	63.2	76	53-76	5.91	0.68
1987	63.0	34	54-85	6.52	1.12
1986	67.6	19	60-83	6.14	1.41
Combined 1986-90	66.6	301	53-97	7.42	0.43

¹ As used here, incubation period is the time (in days) from when eggs were laid until the first hatchlings emerged from the nest.

Table 4. Hatching success summary of 89 green turtle nests at Tern Island, French Frigate Shoals, 1990.

Item	Total	% of Total Eggs	x (Range)	SD	SE	# nest with Item	% nests with Item
Eggs	8135	100	91.4(33-138)	18.90	2.00	89	100.0
Alive Hatched	6363	78.2	71.5(0-129)	28.54	3.03	84	94.4
Escaped Unassisted	5775	71.0	64.9(0-128)	27.60	2.93	84	94.4
Alive-trapped	588	7.2	6.61(0-47)	9.08	0.96	61	68.5
Dead:							
Fully Dev'd	148	1.8	1.66(0-19)	3.65	0.39	35	39.3
3/4 Dev'd	165	2.0	1.85(0-28)	4.02	0.43	42	47.2
1/2 Dev'd	135	1.7	1.52(0-20)	2.88	0.30	41	46.1
1/4 Dev'd	39	0.5	0.44(0-7)	1.23	0.13	16	18.0
Bad Eggs ¹	1285	15.8	14.4(0-109)	20.05	2.13	80	89.9

¹ This category includes all rotten and/or infertile eggs that did not show any signs of development.

Table 5. Hatching success summary of 103 green turtle nests at Tern Island, French Frigate Shoals, 1989.

Item	Total	% of total eggs	\bar{x} (range)	SD	SE	# nests with item	% nests with item
Eggs	9170	100.0	89.0(44-127)	17.47	1.72	103	100.0
Alive Hatched	7514	81.9	73.0(0-124)	23.84	2.35	101	98.1
Escaped unassisted	7290	79.5	70.8(0-125)	24.17	2.38	101	98.1
Alive-trapped	224	2.4	2.2(0-37)	4.78	0.47	48	46.6
Dead:							
Fully Dev'd	67	0.7	0.7(0-7)	1.33	0.13	34	33.0
3/4 Dev'd	261	2.8	2.5(0-32)	4.52	0.45	59	57.3
1/2 Dev'd	128	1.4	1.2(0-17)	2.92	0.29	33	32.0
1/4 Dev'd	55	0.6	0.5(0-6)	1.16	0.11	25	24.3
Bad eggs ¹	1145	12.5	11.1(0-84)	14.30	1.41	97	94.2

¹ This category includes both rotten and infertile eggs.

Table 6. Hatching success summary of 85 Green turtle nests at Tern Island, French Frigate Shoals, 1988.

Item	Total	% of total eggs	\bar{x} (range)	SD	SE	# nests with item	% nests with item
Eggs	8232	100.0	96.8(54-146)	17.99	1.95	85	100.0
Alive Hatched	6603	80.2	77.7(0-124)	28.15	3.05	82	96.5
Escaped unassisted	6069	73.7	71.4(0-114)	27.27	2.96	82	96.5
Alive-trapped	534	6.5	6.3(0-68)	11.35	1.23	55	64.7
Dead:							
Fully Dev'd	79	1.0	0.9(0-20)	2.53	0.27	26	30.6
3/4 Dev'd	179	2.2	2.1(0-16)	3.15	0.34	47	55.3
1/2 Dev'd	141	1.7	1.7(0-19)	3.03	0.33	42	49.4
1/4 Dev'd	95	1.2	1.1(0-10)	2.11	0.23	29	34.1
Bad eggs ¹	1135	13.8	13.4(0-114)	22.28	2.42	81	95.3

¹ This category includes both rotten and infertile eggs.

Table 7. Hatching success summary of 48 green turtle nests at Tern Island, French Frigate Shoals, 1987.

Item	Total	% of Total Eggs	\bar{X} (Range)	# Nests with item	% Nests with item
Eggs	4,161	100.0	86.7 (36-117)	48	100.0
Alive hatched	3,137	75.4	65.4 (0-102)	46	95.8
Escaped unassisted	2,655	63.8	55.3 (0-96)	46	95.8
Alive-trapped	448	10.8	9.3 (0-38)	37	77.1
Alive with yolk sac	34	0.8	0.7 (0-11)	6	12.5
Dead Fully dev'd	88	2.1	1.8 (0-12)	22	45.8
3/4 dev'd	120	2.9	2.5 (0-11)	31	64.6
1/2 dev'd	110	2.6	2.3 (0-19)	27	56.3
1/4 dev'd	76	1.8	1.6 (0-23)	17	35.4
Infertile	61	1.5	1.3 (0-14)	15	31.3
Rotten	569	13.7	11.9 (0-67)	43	89.6

Table 8. Hatching success summary of 23 green turtle nests at Tern Island, French Frigate Shoals, 1986.

Item	Total	% of Total Eggs	\bar{x} (Range)	# Nests with item	% Nests with item
Eggs	1,969	100.0	85.6 (63-119)	23	100.0
Alive hatched	1,670	84.8	72.6 (30-112)	23	100.0
Escaped unassisted	1,456	73.9	63.3 (21-109)	23	100.0
Alive-trapped	214	10.9	9.3 (0-60)	21	91.3
Dead Fully dev'd	5	0.3	0.2 (0-1)	5	21.7
1/2 to 3/4 dev'd	53	2.7	2.3 (0-11)	17	73.9
Infertile or Rotten	241	12.2	10.5 (0-48)	22	95.6

Table 9. Hatching success of green turtles at Tern Island, French Frigate Shoals, 1986-90 seasons.

Year	# Nests	Total # Eggs	Hatched(%) ¹	Trapped(%) ²	Full(%)	Dead - 3/4(%)	Stage of Development - 1/2(%)	1/4(%)	Bad Eggs
1990	89	8135	6363(78.2)	588(7.2)	148(1.8)	165(2.0)	135(1.7)	39(0.5)	1285(15.8)
1989	103	9170	7514(81.9)	224(2.4)	67(0.7)	261(2.8)	128(1.4)	55(0.6)	1145(12.5)
1988	85	8232	6603(80.2)	534(6.5)	79(1.0)	179(2.2)	141(1.7)	95(1.2)	1135(13.8)
1987	48	4161	3137(75.4)	448(10.8)	88(2.1)	120(2.9)	110(2.6)	76(1.8)	630(15.2)
1986	23	1969	1670(84.8)	214(10.9)	5(0.3)	-----	53(2.7) ³	-----	241(12.2)

¹This category consists of all hatchlings that made it out of the nest alive (escaped on their own and trapped ones that were rescued).

²These trapped hatchlings are also included in the "Hatched" category.

³All partially developed hatchlings were lumped together in 1986.

Hatching Success

Nest success data can be found in Appendix A for individual 1990 nests. Data for individual nests from 1989, 1988, 1987 and 1986 can be found in the previous years' "Summary Reports". A summary of hatching success parameters for the five years of work on tern Island can be found in Table 9. Tables 4, 5, 6, 7, and 8 contain individual year summaries for 1990, 1989, 1988, 1987, and 1986, respectively.

In 1990, one of the 90 nests was completely destroyed by a subsequent nesting attempt. Hatching success data is based on the remaining 89 nests. Five of the remaining nests did not hatch. Upon excavation we found no evidence of any development in any of the eggs from these five nests. The percent of eggs that hatched (defined as the number of eggs that produce hatchlings that made it out of the nest alive, either on their own or trapped hatchlings that were rescued) has been relatively constant the last five years, ranging from 75.4% in 1987 to 84.8% in 1986 (Table 9.). A total of 6,363 hatchlings entered the ocean from Tern Island this season; making the total for the last five years 25,287.

In 1990, none of the "trapped" hatchlings were trapped by any man-made debris. The percent of eggs that resulted in trapped hatchlings (still in the nest upon excavation) was 7.2, 2.4, 6.5, 10.8, and 10.9 for 1990 through 1986, respectively (Table 9). Nests were excavated the day after hatchling emergence in 1986 and 1987, two to three days after hatchling emergence in 1988, four days after emergence in 1990, and five days after emergence in 1989. These data show that some of the "trapped" hatchlings encountered when nests are dug up one or two days after hatchling emergence probably could eventually emerge on their own.

In their struggles to free themselves are these "trapped" hatchlings expending energy needed for their survival at sea? Does each additional day spent struggling to escape the nest diminish their chances of survival? How many days after the initial emergence should the nest be excavated? For now, lets plan on excavating nests three days after initial hatchling emergence, a compromise between the one to five day periods used in previous years.

The percent of eggs that are bad (rotten or infertile) has remained relatively constant during the last five years ranging between 12.2 and 15.8% (Table 9.).